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IV. On an ebbing and flowing stream discovered by boring in the harbour of Bridlington. By John Storer, M. D. Communicated by the Right Hon. Sir Joseph Banks, Bart. K. B. P. R. S.

Read January 19, 1815.

THE following account of certain peculiarities attending a spring of fresh water, which was tapped in boring within the harbour of Bridlington quay, Yorkshire, is given from repeated observations made during a residence of some weeks there, in the months of July and August, 1814. The harbour of Bridlington quay is dry at low water, except for a rivulet which traverses its bed: at high water, it has from fifteen to seventeen feet of water.

Mr. RENNIE, civil engineer, was consulted in the year 1811, respecting certain improvements projected in that harbour. At his desire, with a view to ascertain the depth of the stratum of clay in the harbour, the boring, which terminated in forming the well to be described, was begun under the direction of Mr. MILNE, collector of the customs for the port. The spot fixed upon is opposite to the termination of a street leading to the harbour, and has about six feet of water, at high water, in ordinary tides.

After the workmen had bored through twenty-eight feet of very solid clay, and afterwards through fifteen feet of a cretaceous flinty gravel, of a very concrete texture, the auger was perceived to strike against the solid rock; but as they were not

able to make any impression upon it, the work was given up for that tide, without any appearance of water from the first. In an hour or two afterwards, the bore was found filled to the top with fresh water, of the most limpid appearance: it soon flowed over, and was even projected some inches above the summit of the bore, in a stream equal to its calibre. When it was ascertained that the water was of the purest quality and taste, perfectly fit for washing, and every culinary purpose, the bore was properly secured by an elm stock, ten feet long, and perforated with a three inch auger, driven to its full length: a copper tube, well tinned on both sides, of a circumference to admit its being passed through the bore of elm stock, and thirty-two feet in length, was then forced to the bottom of the bore, so as to rest on the rock. The upper part being properly puddled round the elm stock, and the well thus completed, the following singular circumstances were observed, and have continued with great uniformity ever since.

As soon as the surface of the sea water in the harbour, during the flowing tide, has arrived at a level of forty-nine or fifty inches lower than the top of the bore, the water begins to flow from it, in a stream equal to its calibre, the impetus of which is increased as the tide advances, and may be observed to be propelled with much force after the bore is overflowed by the tide. The discharge continues from four to five hours, *i. e.* till the tide in returning falls to the same level where it began to flow: at this point, it ceases completely till the next flood shall have regained the same level, when the same phenomena recur, in the same succession; and without any variation, but what arises from the different degrees of elevation in the tides. The rule appears to be, that the

column of spring water in the bore, is always supported at a height of forty-nine or fifty inches above the level of the tide, at any given time. This at least was the result of every observation I made during several successive weeks, in the months of July and August last; and I am assured by Mr. MILNE, on whose ingenuity and habit of accurate observation I can place the firmest reliance, that his habitual experience, for three years past, goes to convince him, that the variations from the rule stated above, are very inconsiderable during the summer and autumnal months; but that in winter, after any unusual fall of rain, he has known the column of fresh water raised eight feet above the level of the tide, and the period of its discharge proportionally prolonged.

For the use of the town and shipping, a reservoir of brick-work, capable of containing one thousand gallons, has been constructed within two or three yards, and upon somewhat a higher level than the summit of the bore, and is made to communicate with it by a tube of the same diameter, fitted with a valve, to prevent any reflux into the well. Two waste pipes are placed within a foot of the top of the reservoir, for the regular discharge of the water, and it has also been made to communicate with a pump adjoining, by which the reservoir may be emptied; and as the bore of the well is now closed and secured at the top, it is obvious that the commencement of the flow of water, from the pipes of the reservoir, will happen a few minutes sooner or later at each tide, according to the quantity of water it contained at the time. Such, however, is the known regularity of the discharge from the waste pipes, that at the expected time of the tide several of the inhabitants are always on the spot with

their vessels, and are rarely obliged to wait for more than five minutes.

Such is the state of facts, and it appears to open a subject of curious investigation to those whose habits and practical knowledge qualify them for it. The appearances seem not to admit of any satisfactory explanation, without supposing some mode of subterranean communication, by which the water of the sea, and that of the spring in question, are brought into actual contact, so as to exert a reciprocal action. This supposition receives considerable support from a circumstance which I had no opportunity to observe, but which MR. MILNE has had frequent occasion to notice; and which he describes by remarking, that after stormy weather, when there is a heavy sea on that coast, the water is discharged, even from the waste pipes of the reservoir, with an evident undulation; which, of course, would be more considerable from the original bore.

MR. MILNE has framed an hypothesis to satisfy his own mind on this curious subject. He believes the stratum of clay found in the harbour, to extend over the whole bay in front of it, as far as the Smithwick sand, which forms a bar across the opening of the bay, in a direction from Flamborough head towards the Spurn point, and about four miles from the quay in a south-easterly direction. This bank is supported by a reef of rock; and though there are openings, which are well known, and admit vessels of considerable burden at all times of the tide, there is in general but a small draft of water on this bank, when the tide is out. On the outward or east side, towards the ocean, the rock is quite perpendicular, and a great depth of water is immediately behind it. As the copious source

of water, which has been tapped in the harbour, lies at such a depth, and under a stratum of clay, there is no reason to think that it can be discharged any where in the bay, till it arrives at the ledge of rock where the clay terminates. Here, among the fissures of the rock, it may find its exit ; and this is the more likely, as it is known that the bed of the sea at the back of the Smithwick sand, is at so much a lower level.

Admitting this supposition to be correct, or nearly so, it seems to follow, that the issue of a body of fresh water, through a fissure in rock forming the bed of the sea, would meet with more or less resistance at different times of the tide; because the two columns of fluid in meeting, would act upon one another in the ratio of the altitude of each, taking into the account the difference of their specific gravity ; and thus, if there is any approach to an equilibrium, an operation would result, analogous to the flux and reflux of the tide, near the mouth of rivers.

This hypothesis is specious, and accounts for the flux and reflux of the water from the bore, as well as for the singular undulation of the discharge in a boisterous state of the sea : but the greater relative altitude to which the column of spring water is elevated after much rain, and the consequent prolonged discharge of it during each tide, seems to militate against its correctness ; since, in a case, where by the supposition a balance is nearly established, an additional impetus communicated to the column of spring water, ought to produce the opposite effect, by enabling it to overcome the resistance of the same column of sea water during a longer period of each tide, than under the usual circumstances.

It is not improbable, that this whole subject might be

elucidated, by a more perfect acquaintance with the peculiarities of the springs on this part of the coast, provincially termed *gipsies*. The water in this district of the east riding of Yorkshire, possesses that limpidness which is usual in cretaceous soils; but for many miles of the Wolds behind Bridlington, very little water is to be seen. There are few rivulets, and these are very low in the summer, and most of them quite dry in autumn. The account to be collected from the inhabitants is, that in two or three weeks after the commencement of frost, the springs begin to run copiously; and in many, the water is projected with such impetuosity, as to resemble a *jet d'eau*; it is then that, in the language of the country, it is said, “ the gipsies are up,” and the rivulets overflow.

JOHN STORER.

Nottingham, Nov. 5, 1814.

Drawn up from Notes taken at the time, and on the spot.